PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/22

A1

(11) International Publication Number: WO 98/09454

(43) International Publication Date: 5 March 1998 (05.03.98)

(21) International Application Number: PCT/US97/14409

(22) International Filing Date: 15 August 1997 (15.08.97)

(30) Priority Data:
08/703,122 26 August 1996 (26.08.96) US

(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors: KHAWAND, Jean; 13552 S.W. 5th Street, Miami, FL 33184 (US). HEESCHEN, David, R.; 5117 N.W. 47th Avenue, Coconut Creek, FL 33073 (US).

(74) Agents: DOUTRE, Barbara, R. et al.; Motorola Inc., Intellectual Property Dept., 8000 West Sunrise Boulevard, Fort Lauderdale, FL 60196 (US).

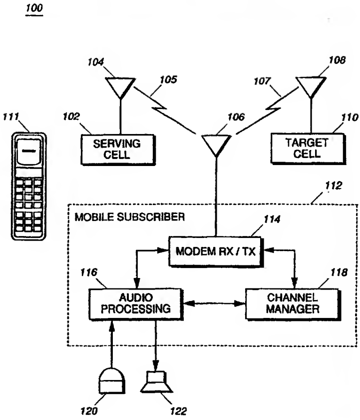
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: COMMUNICATION SYSTEM WITH ZERO HANDOVER MUTE

(57) Abstract

A communication system (100) provides for the elimination of handover mute when switching from a serving cell (102) to a target cell (110) is desired. Once the need for a handover is detected (404), the system (100) searches for the presence of non-voice activity (406). The absence of voice activity is then acted upon by the system (100) to initiate (412) and complete (414) the handover. Since no conversation is taking place, no mute is detected by the users.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

COMMUNICATION SYSTEM WITH ZERO HANDOVER MUTE

Technical Field

This invention is generally related to communication systems and more particularly to systems having a number of control stations.

Background

In communication systems, such as cellular systems, a mobile communication device can communicate with other communication devices while traveling from the zone of one central station (serving cell) to that of another (target cell). A problem that is often encountered in such systems is the muting of the voice that is experienced by a user during a handover. Handover is the period of time during which the communication is handed over from the serving cell to the target cell. The handover process requires that the mobile unit leave the serving cell and adjust to the new timing requirements of the target cell (synchronization). Further, the mobile unit must notify the target cell of its presence thereon. Next, the telephone call must be routed by the fixed network to the target cell for routing to the mobile unit.

Attempts have been made to minimize the duration of this mute. In general, the present methods of reducing the handover mute utilize fast execution routines to rapidly accomplish the handover. Regardless of the speed of the handover process, one can see that the possibility of a mute is not diminished and only the duration of the mute is reduced.

A need exists to overcome the deficiencies of the prior art in eliminating the handover mute in multi-cell communication systems.

Brief Description of the Drawings

FIG. 1 shows a communication system in accordance with the present invention.

FIG. 2 shows a flow diagram of the operation of the handover procedure in accordance with the present invention.

FIG. 3 shows the details of a subroutine of the flow diagram of FIG. 2 in accordance with the present invention.

FIG. 4 shows a timeline of the activities that take place to eliminate handover mute in accordance with the present invention.

FIG. 5 shows a timeline of the activities that take place to minimize handover mute in accordance with the present invention.

Detailed Description of the Preferred Embodiment

The process of handing over the communication between two devices which communication goes through a Fixed Network Equipment (FNE) includes a significant drawback. When a device moves out of the coverage zone of a first central station (serving cell) to that of a second central station (target cell) a handover of the call in progress is necessary. This handover often causes muting of the audio communicated between the two communication devices. The present invention eliminates this mute period by first searching for non-voice activity and then proceeding with the handover. The handover is therefore transparent to the users. The details of this procedure will be better understood by referring to a series of drawings where like numerals are carried forward.

Referring to FIG. 1, a block diagram of a communication system 100 in accordance with the present invention is shown. The system 100 includes at least one wireless communication device as represented by 112 which communicates to at least one additional communication device represented by a second communication device 111 via first and second central stations 102 and 110. The second communication device may be a land line device such as a telephone or a second wireless device such as a cellular phone. In order to avoid unnecessary complications, the system 100 is shown without switching stations that may be needed, particularly if

the device 111 is a landline unit. Central station 102 is depicted as the serving cell which means that the communication between device 112 and 111 is conducted through this station when the need to switch to a second station is presented. Conversely, the second station is depicted by the target cell 110 which is the station that the communication is transferred to as the signal conditions demand.

The communication device 112 maintains connection to the two central stations, often referred to as Fixed Network Equipment FNE, via Radio Frequency RF links 105 and 107 as established and maintained via antennas 104, 106, 108. As the communication device 112 moves about its environment it maintains communication with the serving cell 102. The communication device 112, monitors other cells while it is connected to the serving cell 102. As the quality of the RF signal 105 of the serving cell 102 degrades, the communication device 112 selects another cell, the target cell 110, which has superior RF signal quality. Alternatively, the serving cell 102 informs the communication device 112 to switch to a suitable second control station. Once the handover is complete the target cell is referred to as the serving cell. The present invention aims to minimize and in most instances eliminate the handover mute that results as the communication is migrated from cell 102 to cell 110.

The communication device 112 is comprised of a modem 114, an audio processing block 116, and a channel manager 118. The modem 114 encodes and decodes the data that is transmitted and received via the antenna 106. It sends and receives voice data to and from the audio processing block 116. The audio processing block 116 in turn presents the user with audio via the speaker 122 and captures audio from the user via the microphone 120. The channel manager 118 receives RF signal quality information from the modem 114 and transmits channel access information such as handover requests to the modem 114. In addition, the channel manager 118 monitors inbound and outbound voice activity from the audio processing block 116 so that it may schedule handovers when zero handover mute times will be possible. In the preferred embodiment, most of the component of the communication device 112 are realized via a Digital Signal Processor (DSP). Some of the individual components shown herein are realized via routines executed by the DSP.

Referring to FIG. 2, a detailed flow 200 of the operation of the channel manager 118 is presented. The channel manager runs in order to determine if a handover is required and once one is required it schedules it so that the audio mute time will be minimized with the goal being a zero audio mute time.

The process is begun at the start point 202 whenever the channel manager is invoked. It first checks to see if a handover command has been received from the FNE 204. Normally, conditions are such that a handover is not required and therefore the result of the check 204 is "NO" so that the flow continues on and checks 206 to see if a previous handover command is pending or one has been flagged. Again, when conditions are such that a handover is not required, the "NO" result causes the channel manager to continue with other unspecified tasks. When a pending handover is flagged and/or is in queue, the operation continues with block 210 which is explained later in conjunction with the main flow of the diagram 200. The detection as to whether a handover is needed may be via a demand generated by the device 112 or the stations 102 or 110. The need for a handover may be established by having the serving station 102 measure the delay associated with an outbound or inbound signal. Alternatively, the signal strength of inbound or outbound signals may be evaluated to determine if a handover is needed.

When a handover command is received, the condition block 204 yields a "YES" which starts the handover processing. A forced handover timer is begun, 208. The purpose of this timer is to keep the channel manager from waiting too long for a zero audio mute handover opportunity since the FNE (serving 102 and target 110) expects handovers to be completed within a set time limit. If the handover is not completed on the first attempt the channel manager will run again but since the handover command was previously received the timer will not be restarted since the flow will avoid this by passing through the handover pending block 206.

In either of the previous cases, the channel manager will update its status of inbound and outbound non-voiced frames via a subroutine block 210. The details of this update are contained in FIG. 3. Once the update is completed, the channel manager checks 212 to see if the forced handover timer has expired. This condition occurs when no pauses or pauses of

insufficient duration have been detected. Following the YES output of the condition block 212, the communication device 112 must perform the handover immediately to satisfy the FNE's time limit on handovers and get whatever audio mute that occurs. In this case, the "YES " path is taken and the handover is performed 216. As part of the handover, the serving station 102 informs the communication device 112 to continue communicating with the device 111 through the target station 110. This is the safety path as it is desirable to proceed with the handover even if a short mute is experienced as opposed to losing the communication all together (dropping the call). If however, the time-out has not occurred the "NO" path is taken where the channel manager checks to see if the correct number of inbound (N) and outbound (M) non-voiced frames have occurred, block 214. A limit for each is maintained by the communication device 112 which, if achieved, predicts that a natural pause is occurring in the conversation and that the time is ripe for the handover. If the limits have been achieved then the "YES" path is taken and the handover is performed, 216. This is the most desirable path for the handover mute algorithm to take as no mute is experienced by the system. Otherwise the "NO" path is taken and channel will re-evaluate its handover opportunity on its next invocation. The re-evaluation will occur until an opportunity is presented or the forced handover timer expires.

In accordance with the principles of the present invention, parameters N and M may be fixed for a particular application or may take configurable formats. These parameters may be stored in volatile or non-volatile, programmable or non-programmable memory devices. These parameters may be established dynamically by monitoring the natural pauses, such as voice nulls or inter-syllabic pauses, in a person's speech. The communication device 112 may include an algorithm by which the user produced inadvertent and inter-syllabic pauses are monitored to determine their average time span. Depending on the speed with which a handover can be completed in a particular system, this adaptively measured pause time may be used to complete the handover without seeking advertent pauses in the communication.

FIG. 3 shows the blocks of the "update silence period" subroutine 210. Its purpose is to count the number of consecutive non-voiced frames in both the inbound and outbound direction. It is noted that having a

number of consecutive non-voiced frames is an indicator of a natural pause in the conversation which is the most opportune time to perform a handover.

The first step is to check if the inbound frame is voiced or non-voiced, 302. The audio processing block 116 of FIG. 1 provides this information to the channel manager 118 as it prepares the audio sampled by the microphone 120 and determines if voice was present or not. If voice is detected the "NO" path is taken and the counter of inbound non-voiced frames is reset, 306. Otherwise, no voice is detected and the "YES" path is taken thus incrementing the inbound non-voiced frame counter, 304. Whether the counter is reset or incremented, the operation continues with block 308 where a decision is made regarding the nature of the outbound frame.

The audio processing circuit 116 of provides this information to the channel manager 118 as it processes data received from the FNE and determines if voice is contained therein. If voice is detected, the "NO" path is taken and the counter of outbound non-voiced frames is reset, 312. Otherwise, no voice is detected and the "YES" path is taken thus incrementing the outbound non-voiced frame counter, 310.

Finally, the silence period is calculated by monitoring the number of consecutive inbound and outbound non-voice frames that have occurred, 314. The goal at this juncture is to make sure that the number of non-voice frames in each direction is sufficient for a handover to take place without a mute. This step is highly dependent on the capabilities of the system 100 in completing a handover. The shorter the time needed for this task, the fewer the number of required frames. Consequently, a fast system affords its users with more handover opportunities in a typical communication, hence a significantly reduced possibility of mute. Once the calculation of the silence period is done, block 316 returns the control to block 212 in FIG. 2.

To better understand the operation of the system described above, a series of time lines are presented in FIGs. 4 through 5. These timelines show the activities that take place as time is progressed in order to minimize the mute time when a handover is desired. Three different scenarios are presented in an effort to cover all possible situations in which a handover is desired or is necessary.

Referring first to FIG. 4, a timing diagram of a handover that occurs during a natural non-voiced portion of a conversation is presented. This timeline begins with either inbound or outbound voice activity on the serving cell, 402. During this time 402 a handover command (assignment) 404 is received by the communication device 112. The communication device 112 begins its search for consecutive non-voiced frames and starts the forced handover timer, 420. As mentioned earlier, this timer is maintained to avoid missing a handover simply because a sufficient number of consecutive non-voiced frame were not detected. In other words, it is desired to handover with a mute than not to handover at all which results in the loss of communication.

Eventually, sufficient inbound and outbound non-voiced frames are detected by the communication device 112 and is referred to as the silence detection period (SDP), 406. As can be seen, the actual pause in the voice 408 will extend beyond the SDP and the handover; this is the desired result of the present invention. Once the SDP has occurred the handover and the associated mute 410 take place. Indeed, the handover is started 412 following the SDP and is noted complete by the end handover ticker 414. During this handover period the speaker 122 is muted, 410. Since the handover mute occurs during the natural voice pause it is not noticed by the parties involved in the conversation and in fact has a significant margin for error, 411. The conversation naturally resumes in either the inbound or the outbound direction using the target cell 416. Because a handover opportunity readily occurred the timer did not expire and a forced handover 418 was not necessary. As such, the muting of the speaker 122 during the handover period was not necessary.

FIG. 5 shows a timing diagram of a handover that occurs during a short natural non-voiced portion of a conversation. It begins similarly to the timing diagram of FIG. 4 where an inbound or outbound voice is in progress using the serving cell 102. Because the voice pause 508 is short, the handover period which starts at the end of SDP 506 as shown by 512 extends beyond the non-voice activity and ends, 514 when the target cell 110 has taken over the communication, 516. In other words, the handover runs into the next voiced frame thus causing some unwanted lost audio 511. The lost audio is less than the entire duration of the handover and is still beneficial. This is significant as the handover mute is minimized

when non-voice activity does not continue for a sufficiently long period of time. It is noted that the condition depicted by this timing diagram of FIG. 5 occurs in the rare occasions where speech continues uninterrupted and no pauses (advertent or inadvertent) of sufficient duration (measured in terms of the handover speed of the system 100) have occurred.

In summary, a handover mute elimination/minimization procedure is presented whereby the switching from a serving cell to a target cell in a multi-cell communication system is accomplished with minimum impact on the conversation between the parties. Once the need for a handover is detected, the system searches for the presence of non-voice activity. The absence of voice activity is then acted upon by the system to initiate and complete the handover. Since no conversation is taking place, the handover is transparent to the users. The handover is preferably implemented in a shorter period of time than the length of the non-voice activity. This condition eliminates muting of the voice during the handover.

What is claimed is:

Claims

1. In a communication system having at least one wireless communication device, at least one additional communication device, and first and second central stations, a method for handing over control of communication between the communication devices from the first to the second central station, comprising the steps of:

flagging the need for a handover;

detecting a pause in voice components of the communication to establish a detected pause; and

handing over the control of the communication between the communication devices when the detected pause exceeds a predetermined period of time.

2. The method of claim 1, further including the step of handing over the control of communication between the communication devices from the first to the second central station when no pause in voice communication has been detected for a period of time.

3. The method of claim 1, wherein the step of flagging includes detecting a handover assignment.

4. The method of claim 1, wherein the step of detecting a pause includes the step of detecting a pause having a configurable duration.

5. The method of claim 1, wherein the step of handing over includes the step of the first central station informing the at least one wireless communication device to migrate to the second central station.

6. In a communication system having a plurality of control stations for controlling communication between first and second communication devices at least one of which is a wireless communication device, a method for handing over control of the communication from one control station to another, comprising:

detecting when a change in the control station is desired;

monitoring voice communication between the first and second communication devices to detect the absence of voice activity for a selectively variable period of time; and

handing over control of the communication from one control station to another during the absence of voice activity to minimize muting effects.

7. The method of claim 6, wherein the step of detecting includes the step of setting a flag when a change in the control station is desired.

8. The method of claim 6, wherein the step of monitoring includes the step of detecting a voice null.

9. The method of claim 6, wherein the step of monitoring includes the step of detecting a voice pause.

10. The method of claim 6, further including the step of handing over control of the communication from one control station to another when no absence of voice activity has been detected for a predetermined period of time.

11. The method of claim 6, further including the step of handing over control of the communication from one control station to another when a sufficiently long absence of voice activity has been detected to eliminate muting of voice.

12. In a communication system having first and second communication processing stations for processing radio frequency communication between at least one wireless communication device and a second communication device, a method of handing over communication from the first communication processing station to the second communication processing station, comprising:

detecting when the at least one wireless communication device has traveled outside a predetermined range of the first communication processing station;

monitoring the voice communication between the at least one wireless communication device and the second communication device in search of a voice pause;

discovering the absence of voice in the communication from the at least one wireless communication device to the second communication device; and

handing over processing of radio frequency communication from the first to the second communication processing station during the absence of voice in order to minimize the muting of voice.

13. The method of claim 12, wherein the step of detecting included monitoring at the first communication processing station the delay associated with an outbound signal into the first communication processing station.

14. The method of claim 12, wherein the step of detecting included monitoring at the first communication processing stations the signal strength of an inbound signal into the first communication processing station.

15. The method of claim 12, wherein the second communication device is a second wireless communication device.

16. The method of claim 12, wherein the step of handing over includes informing the wireless communication device to switch to the second communication processing station.

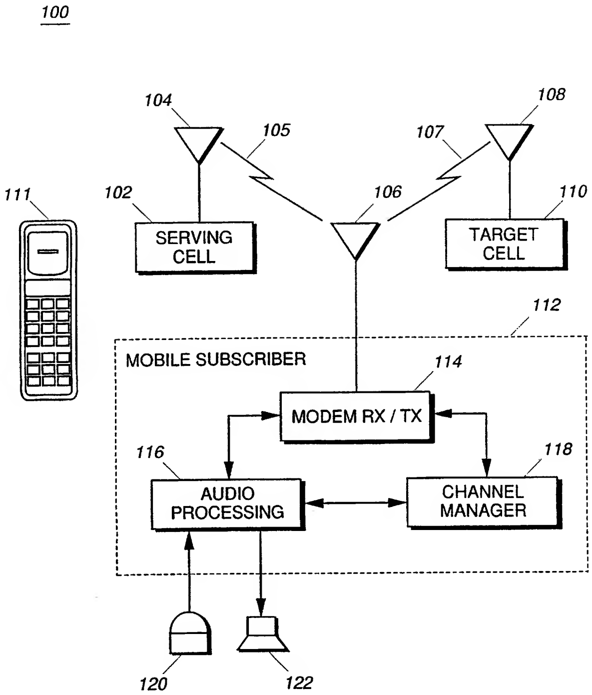

100
104
105
107
108
111
102
106
110
SERVING CELL
TARGET CELL
112
MOBILE SUBSCRIBER
114
MODEM RX / TX
116
118
AUDIO PROCESSING
CHANNEL MANAGER
120
122

FIG. 1

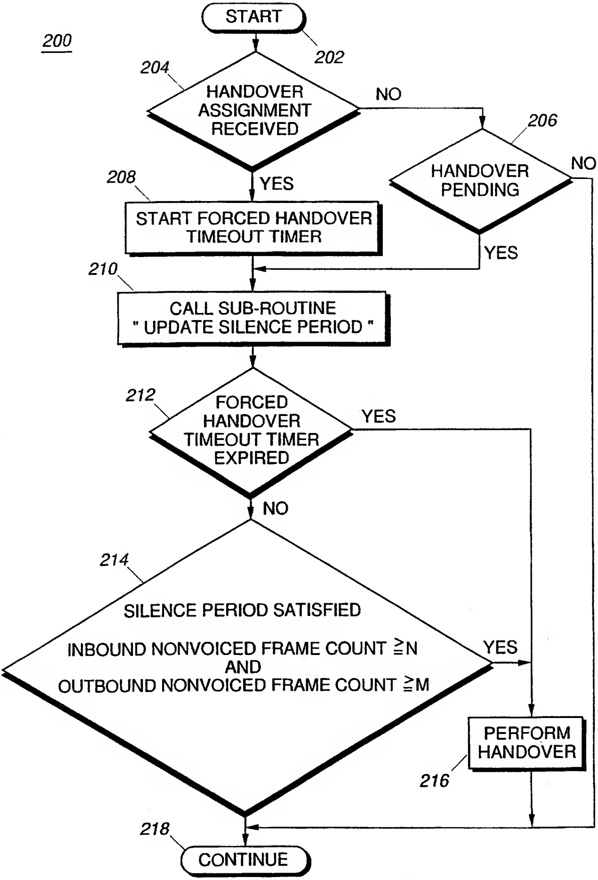

200
START
202
204
HANDOVER ASSIGNMENT RECEIVED
NO
206
HANDOVER PENDING
NO
208
YES
START FORCED HANDOVER TIMEOUT TIMER
YES
210
CALL SUB-ROUTINE " UPDATE SILENCE PERIOD "
212
FORCED HANDOVER TIMEOUT TIMER EXPIRED
YES
NO
214
SILENCE PERIOD SATISFIED
INBOUND NONVOICED FRAME COUNT ≧N
AND
OUTBOUND NONVOICED FRAME COUNT ≧M
YES
PERFORM HANDOVER
216
218
CONTINUE

FIG. 2

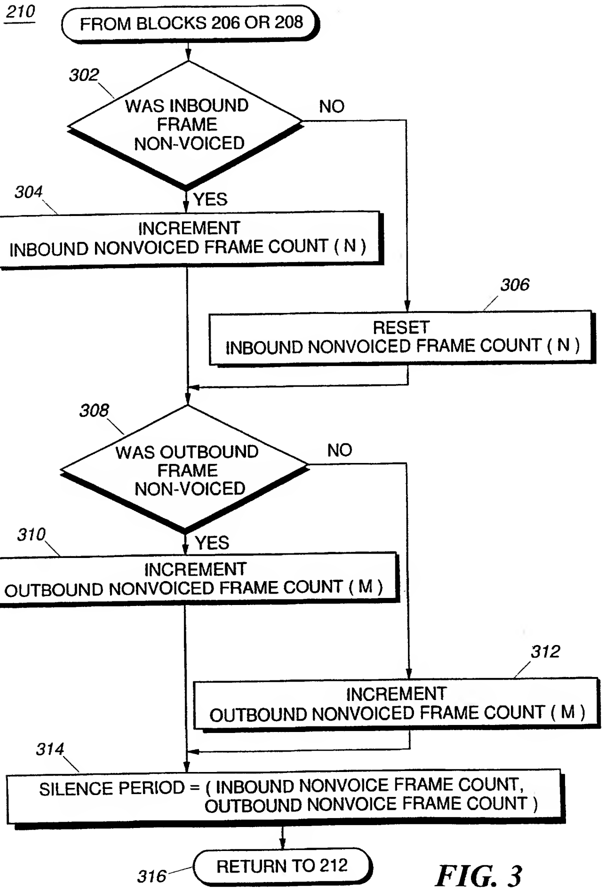

210
FROM BLOCKS 206 OR 208
302
WAS INBOUND FRAME NON-VOICED
NO
YES
304
INCREMENT INBOUND NONVOICED FRAME COUNT (N)
306
RESET INBOUND NONVOICED FRAME COUNT (N)
308
WAS OUTBOUND FRAME NON-VOICED
NO
YES
310
INCREMENT OUTBOUND NONVOICED FRAME COUNT (M)
312
INCREMENT OUTBOUND NONVOICED FRAME COUNT (M)
314
SILENCE PERIOD = (INBOUND NONVOICE FRAME COUNT, OUTBOUND NONVOICE FRAME COUNT)
316
RETURN TO 212

FIG. 3

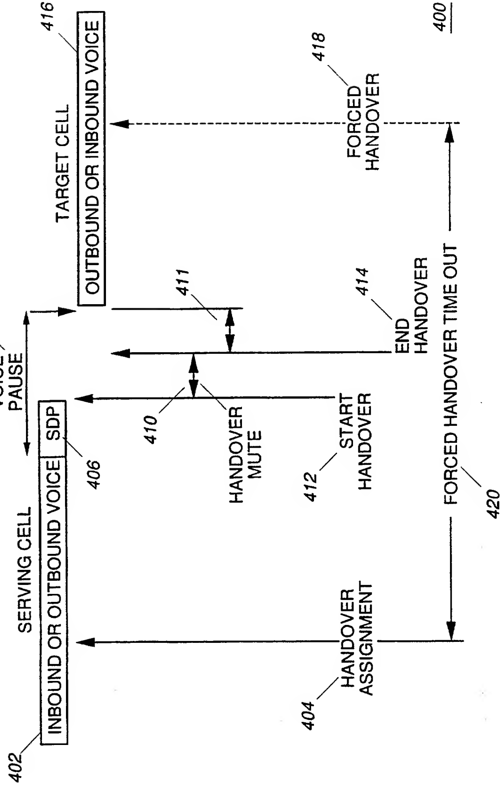

SERVING CELL
INBOUND OR OUTBOUND VOICE
SDP
402
406
VOICE PAUSE
408
TARGET CELL
OUTBOUND OR INBOUND VOICE
416
HANDOVER ASSIGNMENT
404
HANDOVER MUTE
410
411
START HANDOVER
412
END HANDOVER
414
FORCED HANDOVER
418
FORCED HANDOVER TIME OUT
420
400

FIG. 4

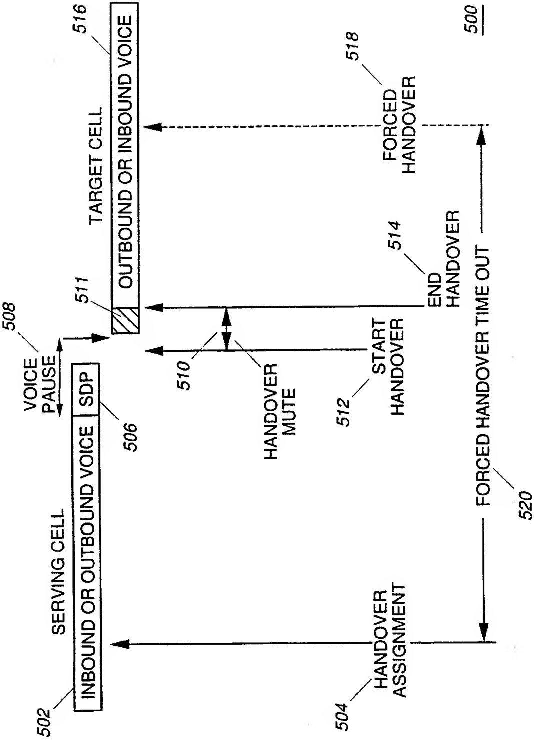

516
TARGET CELL
OUTBOUND OR INBOUND VOICE
518
FORCED HANDOVER
500
508
VOICE PAUSE
511
514
END HANDOVER
SERVING CELL
INBOUND OR OUTBOUND VOICE
SDP
506
510
HANDOVER MUTE
512
START HANDOVER
FORCED HANDOVER TIME OUT
520
502
504
HANDOVER ASSIGNMENT

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/14409

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04Q 7/22
US CL :455/436
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 455/436, 437, 438, 439, 440, 441, 442, 443, 444

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,829,554 A (BARNES, et al) 09 May 1989, figures 8A to 14B	1-16
Y	US 5,457,680 A (KAMM, et al) 10 October 1995, column 3, line 25 to column 4, line 37	1-16
A	US 5,488,649 A (SCHELLINGER) 30 January 1996	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
16 SEPTEMBER 1997

Date of mailing of the international search report
14 NOV 1997

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
WILLIAM DENNIS CUMMING
Telephone No. (703) 308-4394